Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

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Co-manager review draft

[This is a draft document being provided to state, tribal, and federal comanagers for technical review.]

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A. Chinook salmon

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This section deals specifically with chinook salmon It is part of a larger report, the remaining sections of which can be accessed from the same website used to access this section (http://www.nwfsc.noaa.gov/). The main body of the report (Background and Introduction) contains background information and a description of the methods used in the risk analyses.

A. CHINOOK

A.1 BACKGROUND AND HISTORY OF LISTINGS

Chinook salmon (*Oncorhynchus tshawytscha* Walbaum), also commonly referred to as king, spring, quinnat, Sacramento, California, or tyee salmon, is the largest of the Pacific salmon (Myers et al. 1998). The species historically ranged from the Ventura River in California to Point Hope, AK in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of Northern Canada (McPhail and Lindsey 1970). Of the Pacific salmon, chinook salmon exhibit arguably the most diverse and complex life history strategies Healey (1986) described 16 age categories for chinook salmon, seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to sockeye salmon (*O. nerka*), although sockeye salmon have a more extended freshwater residence period and utilize different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): “stream-type” chinook salmon reside in freshwater for a year or more following emergence, whereas “ocean-type” chinook salmon migrate to the ocean predominately within their first year. Healey (1983, 1991) has promoted the use of broader definitions for “ocean-type” and “stream-type” to describe two distinct races of chinook salmon. This racial approach incorporates life history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations. For this reason, the BRT has adopted the broader “racial” definitions of ocean- and stream-type for this review.

Of the two life history types, ocean-type chinook salmon exhibit the most varied and plastic life history trajectories. Ocean-type chinook salmon juveniles emigrate to the ocean as fry, subyearling juveniles (during their first spring or fall), or as yearling juveniles (during their second spring), depending on environmental conditions. Ocean-type chinook salmon also undertake distinct, coastally oriented, ocean migrations. The timing of the return to freshwater and spawning is closely related to the ecological characteristics of a population’s spawning habitat. Five different run times are expressed by different ocean-type chinook salmon populations: spring, summer, fall, late-fall, and winter. In general, early run times (spring and summer) are exhibited by populations that use high spring flows to access headwater or interior regions. Ocean-type populations within a basin that express different runs times appear to have evolved from a common source population. Stream-type populations appear to be nearly obligate yearling outmigrants (some 2-year-old smolts have been identified), they undertake extensive off-shore ocean migrations, and generally return to freshwater as spring- or summer-run fish. Stream-type populations are found in northern British Columbia and Alaska, and in the headwater regions of the Fraser River and Columbia River interior tributaries.

Prior to development of the ESU policy (Waples 1991), the NMFS recognized Sacramento River winter chinook salmon as a “distinct population segment” under the ESA (NMFS 1987). Subsequently, in reviewing the biological and ecological information concerning West Coast chinook salmon, Biological Review Teams (BRTs) have identified additional ESUs for chinook salmon from Washington, Oregon, and California: Snake River fall-run (Waples et al. 1991), Snake River spring- and summer-run (Matthews and Waples 1991), and Upper Columbia River summer- and fall-run chinook salmon (originally designated as the mid-Columbia River summer- and fall-run chinook salmon, Waknitz et al. 1995), Puget Sound chinook salmon, Washington Coast chinook salmon, Lower Columbia River chinook salmon, Upper Willamette River chinook salmon, Middle Columbia River spring-run chinook salmon, Upper Columbia River spring-run chinook salmon, Oregon Coast chinook salmon, Upper Klamath and Trinity rivers chinook salmon, Central Valley fall and late-fall-run chinook salmon, and Central Valley spring-run chinook salmon (Myers et al. 1998), the Southern Oregon and Northern California chinook salmon, California Coastal chinook salmon, and Deschutes River (NMFS 1999).

Of the 17 chinook salmon ESUs identified by the NMFS, eight are not listed under the United States ESA, seven are listed as threatened (Snake River spring- and summer-run chinook salmon, and Snake River fall-run chinook salmon [Federal Register, Vol. 57, No. 78, April 22, 1992, p. 14653]; Puget Sound chinook salmon, Lower Columbia River chinook salmon, and Upper Willamette River chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]; Central Valley fall-run, and California Coastal chinook salmon [Federal Register, Vol. 64, No. 179, September 16, 1999, p. 5039]), and two are listed as endangered (Sacramento River winter-run chinook salmon [Federal Register, Vol. 59, No. 2, January 4, 1994, p. 440], and Upper Columbia River spring-run chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]).

The NMFS convened a BRT to update the status of listed chinook salmon ESUs in Washington, Oregon, California, and Idaho. The chinook salmon BRT[1] met in January of 2003 in Seattle, WA to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chinook salmon status review included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhaney, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK

A.2.9.1. Previous BRT Conclusions

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring chinook fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring chinook program. Like most spring chinook, CV spring chinook require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500m elevation, and most such habitat in the CV is now behind impassable dams (Figure A.2.9.1). Only three self-sustaining wild populations of spring chinook (on Mill, Deer and Butte creeks, tributaries to the lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on catches in the early gill-net fishery). Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain, and these are apparently dependent on the Feather River Hatchery.

In addition to outright loss of habitat, CV spring chinook must contend with the widespread habitat degradation and modification of their rearing and migration habitats in the natal stream, the Sacramento River, and the Delta. The natal tributaries do not have large impassable dams like many Central Valley Streams, but they do have many small hydropower dams and water diversions that, in some years, have greatly reduced or eliminated in-stream flows during spring-run migration periods. Problems in the migration corridor include unscreened or inadequately screened water diversions, predation by non-native species, and excessively high water temperatures.

The Feather and Yuba Rivers contain populations thought to be significantly influenced by the Feather River Hatchery (FRH) spring chinook stock. The FRH spring chinook program releases its production far downstream of the hatchery, causing high rates of straying (CDFG 2001). There is concern that fall and spring chinook have hybridized in the hatchery. The BRT viewed FRH as a major threat to the genetic integrity of the remaining wild spring chinook populations.

BRT conclusions

In the original chinook status review, a majority of BRT concluded that the CV spring chinook ESU was in danger of extinction (Myers et al. 1998). Listing of this ESU was deferred, and in the status review update, the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (NMFS 1999). A major reason for this shift was data indicating that a large run of spring chinook on Butte Creek in 1998 was naturally produced, rather than strays from FRH.

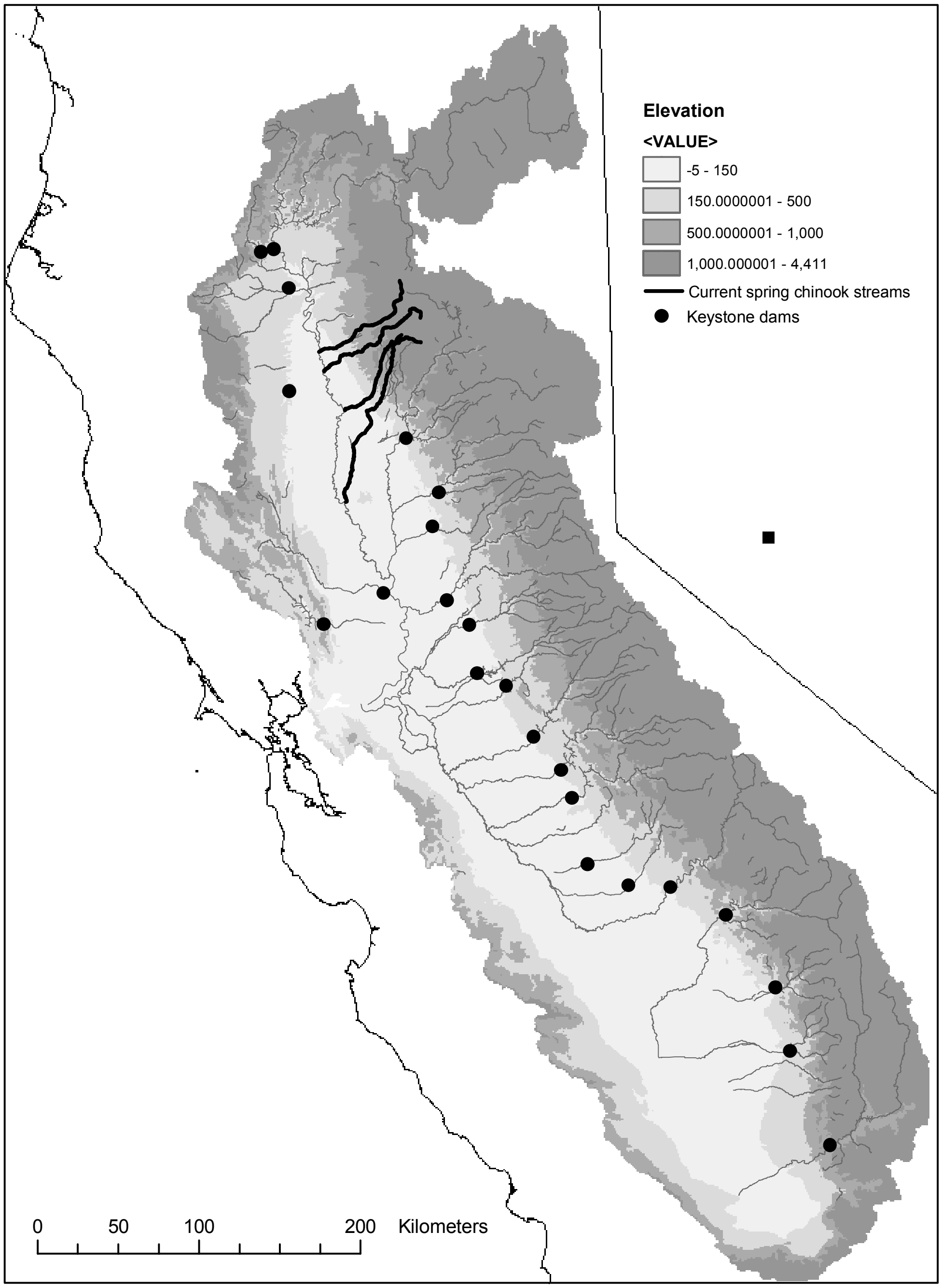

Figure A.2.9.1. Map of Central Valley showing the locations of self-sustaining spring chinook populations. These populations are found in the only watersheds with substantial accessible habitat above 500 m elevation.

Listing status

Central Valley spring chinook were listed as threatened in 1999. Naturally spawning spring chinook in the Feather River were included in the listing, but the Feather River Hatchery stock of spring chinook was excluded.

A.2.9.2 New Data

Status assessments

In 1998, CDFG reviewed the status of spring-run chinook in the Sacramento River drainage in response to a petition to list these fish under the California Endangered Species Act (CESA) (CDFG 1998). CDFG concluded that spring chinook formed an interbreeding population segment distinct from other chinook salmon runs in the Central Valley. CDFG estimated that peak run sizes might have exceeded 600,000 fish in the 1880s, after substantial habitat degradation had already occurred. They blame the decline of spring chinook on the early commercial gillnet fishery, water development that blocked access to headwater areas, and habitat degradation. Current risks to the remaining populations include continued habitat degradation related to water development and use, and the operation of FRH. CDFG recommended that Sacramento River spring-run chinook be listed as threatened under the CESA.

Population structure

There are preliminary results for two studies of spring chinook population structure. Two important insights are provided by these data sets. First, CV spring chinook do not appear to be monophyletic, yet wild CV spring chinook populations from different basins are more closely related to each other than to fall chinook from the same basin. Second, neither Feather River natural (FR) or Feather River Hatchery (FRH) spring chinook are closely related to any of the three wild populations although they are closely related to each other and to CV fall chinook.

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring chinook are not closely related to sympatric fall chinook populations or the FRH spring chinook stock (Figure A.2.9.2). FRH spring chinook, putative Feather River natural spring chinook, and Yuba River spring chinook fell into a large cluster composed mostly of natural and hatchery fall chinook.

Dennis Hedgecock and colleagues, using 12 microsatellite markers, showed that there are two distinct populations of chinook in the Feather River (Hedgecock 2002). One population is formed by early-running ("spring") chinook, the other by late running fish ("fall run"). Once run timing was accounted for, hatchery and naturally spawning fish appear to form a homogeneous population. The Feather River spring population is most closely related to FR fall (F_{st}=0.010) and to Central Valley Fall chinook (F_{st}=0.008) and is distinct from spring chinook in Deer, Mill (F_{st}=0.016) and Butte (F_{st}=0.034) creeks. Figure A.2.9.3 shows the neighbor-joining tree with Cavalli-Sforza and Edwards chord distances and unweighted pair-group method arithmetic averaging.

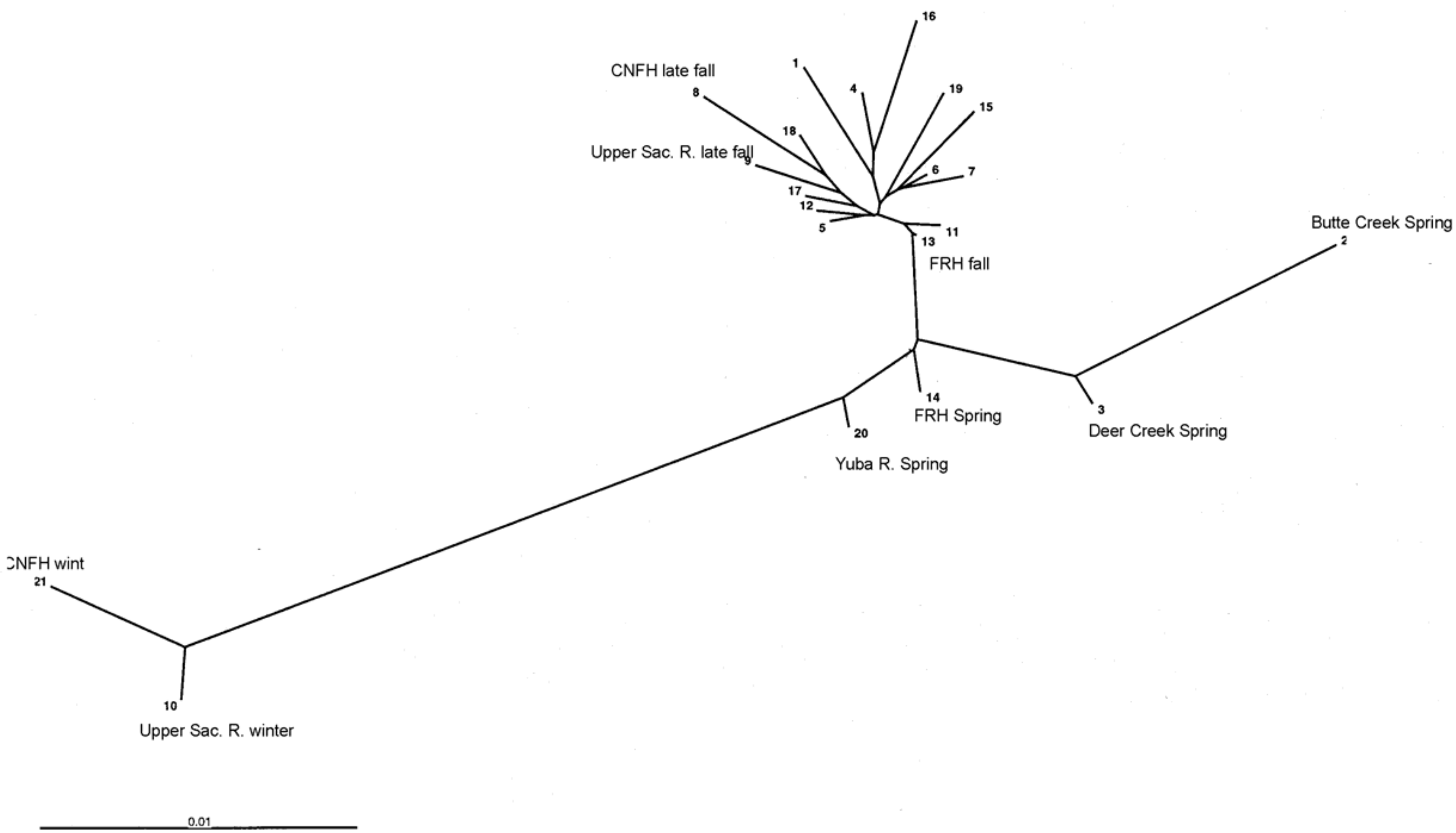

Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall chinook populations.

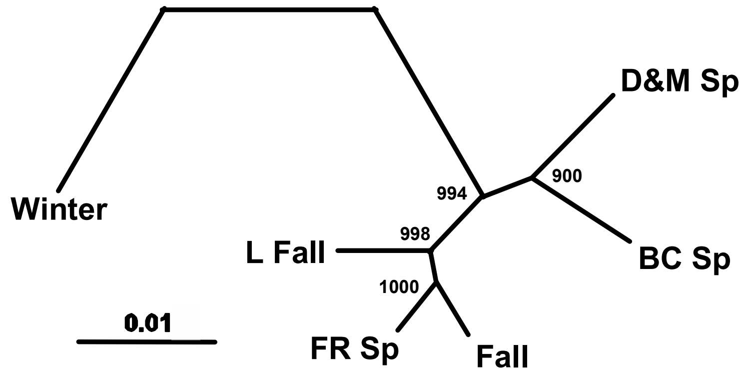

Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring chinook; L Fall = late-fall chinook; Winter = winter chinook. The tree was constructed using Cavalli-Sforza and Edwards measure of genetic distance and the unweighted pair-group method arithmetic averaging. Figure from Hedgecock (2002).

At least two hypotheses could explain the Feather River observations:

1. an ancestral Mill/Deer/Butte-type spring chinook was forced to hybridize with the fall chinook, producing an intermediate form.
2. the ancestral Feather River spring chinook had a common ancestor with the Feather River fall chinook, following the pattern seen in Klamath chinook but different from the pattern seen in Deer, Butte and Mill creeks. The FR and FRH populations have merged.

Hedgecock argues against the first hypothesis. Feather River fish cluster well within Central Valley fall chinook rather than between Mill/Deer/Butte spring chinook and Central Valley fall chinook, as would be expected under hypothesis 1. Furthermore, there is no evidence from linkage disequilibria that FR spring and FR fall populations are hybridizing, i.e., these populations are reproductively isolated. It is perhaps not surprising that Feather River spring chinook might have a different ancestry than spring chinook in Mill, Deer and Butte creek, since the Feather River is in a different ecoregion.

Regardless of the cause of the genetic patterns described above, these new data do not support the current configuration of the CV spring chinook ESU. Feather River spring chinook do not appear to share a common ancestry or evolutionary trajectory with other spring chinook populations in the Central Valley. They share the designation of "spring" chinook, and indeed, the Feather River and FRH have a chinook spawning run that starts much earlier than other Sacramento basin rivers. There is no longer a distinct bimodal distribution to run timing, however, and substantial fractions of fish released as FRH spring chinook have returned during the fall chinook period (and vice versa) (CDFG 1998). If FR and FRH spring chinook are retained in the CV spring chinook ESU, then the ESU configuration of the CV fall-late fall chinook ESU (among several others) should be reconsidered for the sake of consistency, because late-fall chinook are more distinct genetically and arguably as distinct in terms of life history as FRH spring chinook.

Historic habitat loss

Yoshiyama and colleagues detailed the historic distribution of Central Valley spring chinook. Yoshiyama et al. (2001) estimated that 72% of salmon spawning and rearing habitat has been lost in the Central Valley. This figure is for fall as well as spring chinook, so the amount of spring chinook habitat lost is presumably higher, because spring chinook spawn and rear in higher elevations, areas more likely to be behind impassable dams. They deem the 95% loss estimate of CDFG (Reynolds et al. 1993) as "perhaps somewhat high but probably roughly accurate."

Life history

CDFG recently began intensive studies of Butte Creek spring chinook (Ward et al. 2002). One of the more interesting observations is that while most spring chinook leave Butte Creek as young-of-the-year, yearling outmigrants make up roughly 25% of the ocean catch of Butte Creek spring chinook.

New harvest information

Coded-wire tagging of juvenile spring chinook in Butte Creek provides some limited information on current harvest rates of this population. Based on eight CWT recoveries in the ocean fisheries and 15 CWT recoveries in Butte Creek, the harvest rate on age 3 Butte Creek spring chinook is 0.44 (Ward et al. 2002).

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of Central Valley spring chinook is thought to be a function of the Central Valley chinook ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter chinook. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall chinook ($\approx$ 540,000 fish in 2001).

A.2.9.3 New Comments

The State Water Contractors (SWC) submitted several documents, one of them relevant to the status review for CV spring chinook. The document, "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," argues that Feather River spring chinook should not be included in the Central Valley spring chinook ESU and do not otherwise warrant protection under the ESA. SWC also suggested that NOAA Fisheries conduct a series of evaluations of the following topics:

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation

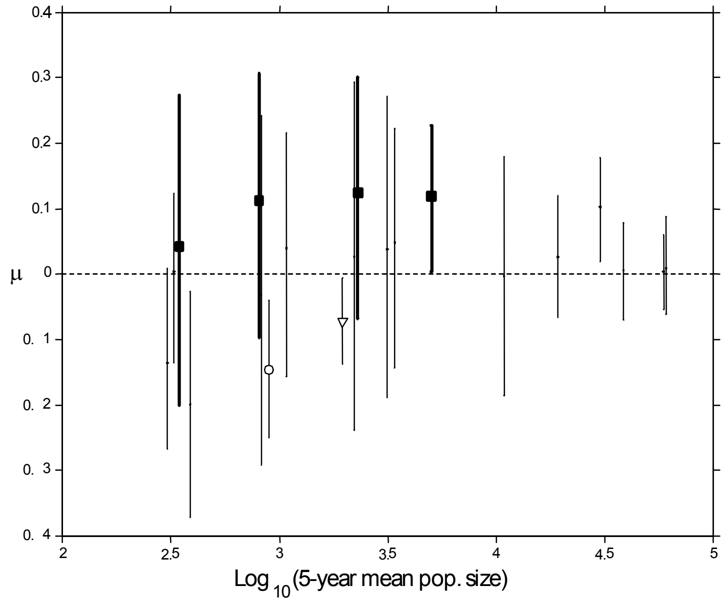

Figure A.2.9.4. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log [\lambda]$.)

3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included (1) an analysis by B.J. Miller showing that significant and expensive changes to water operations in the Delta provide fairly modest benefits to chinook populations; (2) “Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU,” discussed in the preceding paragraph; (3) a memo from J. F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

New abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico creek spring chinook have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant

Table A.2.9.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sac. R. winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Cr. spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Cr. spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Cr. spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial climate.

The time series for Butte, Deer and Mill Creeks are barely amenable to simple analysis with the random walk-wth-drift model (Homes 2001, Lindley in press). The data series are short, and inconsistent methods were used until 1992, when a consistent snorkel survey was initiated on Butte and Deer Creeks. The full records for these three systems are analysed with the knowledge that there may be significant errors in pre-1992 observations. Table A.2.9.1 summarizes the analyses of these time series.

It appears that the three spring chinook populations in the Central Valley are growing. The current five-year geometric means for all three populations are also the maximum 5-year means. All three spring chinook populations have long and short-term $\lambda > 1$ (λ is defined as $\exp(\mu + \sigma^2_p / 2)$--the *mean* annual population growth rate in this document), with lower bounds of 90% confidence intervals generally > 1. Long- and short-term trends are also positive, although some confidence interval lower bounds are negative. Central Valley spring chinook have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall chinook populations (Figure A.2.9.5).

A.2.9.4 New Hatchery Information

FRH currently aims to release 5 million spring chinook smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.5). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.6).

A.2.9.5 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer and Butte creek populations noted in the previous status review have apparently continued. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring chinook are not closely related to the Mill, Deer and Butte creek spring chinook populations.

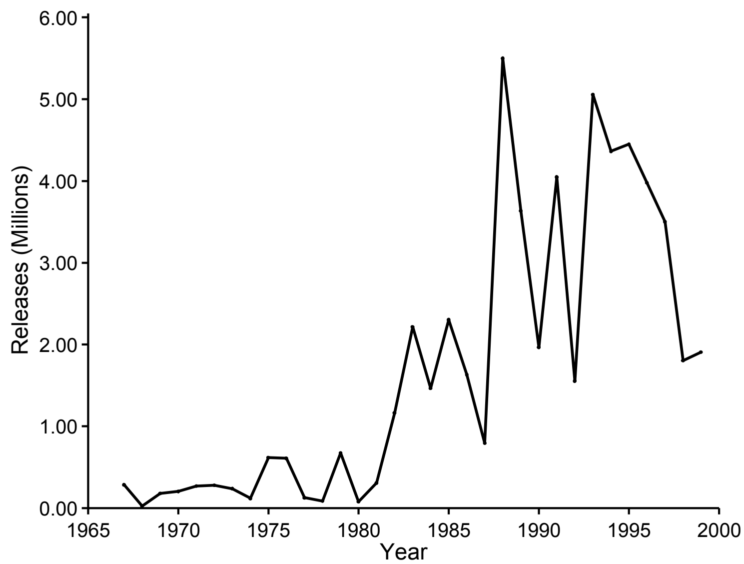

Figure A.2.9.5. Number of spring-run chinook released by Feather River Hatchery.

Figure A.2.9.6. Number of spring-run chinook returning to Feather River Hatchery.